APPENDIX N

GEOTECHNICAL INSTRUMENTATION AND MONITORING PLAN

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GEOTECHNICAL INSTRUMENTATION AND MONITORING PLAN

ONONDAGA LAKE SEDIMENT CONSOLIDATION AREA (SCA) FINAL DESIGN SUBMITTAL

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Project Number GJ4299

January 2010

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1. INTRODUCTION

1.1 Project Background

Onondaga Lake is a 4.6 square mile (3,000 acre) lake located in Central New York State immediately northwest of the City of Syracuse. A major component of the selected lake remedy includes the dredging and onsite consolidation of sediments removed from the lake. Honeywell evaluated potential locations for building and operating a Sediment Consolidation Area (SCA) to contain sediment removed from Onondaga Lake during the remedial action. Based on the evaluation results, Wastebed 13 was selected for building and operating the SCA. Wastebed 13 is located in the Town of Camillus and encompasses approximately 163 acres. It is bordered to the north by Ninemile Creek and the CSX Railroad tracks; to the west by an Onondaga County Garage property, a former gravel excavation owned by Honeywell, and a few residential properties; and to the east and south by Wastebeds 12 and 14, respectively. Wastebed 13 was originally designed as a settling basin for the disposal of Solvay waste (SOLW).

The purpose of the SCA is to contain dredged sediment from the Onondaga Lake remedial action. Geotextile tubes were selected as the dewatering method for the dredged sediment within the SCA. The SCA will have a maximum footprint of approximately 70 acres and will include a perimeter berm, a liner system, a gravel drainage system, stacked geotextile tubes filled with dredged sediment, and a final cap. The SCA design includes a phased construction approach to facilitate the dredging schedule, odor mitigation, underlying Solvay waste consolidation, and/or enhanced final closure.

1.2 Purpose of Instrumentation and Monitoring Program

The purpose of instrumentation and monitoring is to provide data to: (i) evaluate whether the SCA is performing as expected; and (ii) evaluate whether SCA construction and/or operations are impacting SCA and/or Wastebed 13 stability. Specifically, the scope of the Geotechnical Instrumentation and Monitoring Plan (referred to as the Plan) includes: (i) a description of the proposed instrumentation to be installed in the SCA; (ii) recommended procedures for instrument installation; (iii) requirements of instrument operation, data collection, and instrument maintenance; and (iv) recommendations on data management and analysis.

1.3 Plan Organization

The remainder of the Plan is organized as follows:

- Section 2 provides a description of the instrumentation program. It includes a summary of instrumentation to be installed in the SCA, the requirements for testing and calibration of instrument components, the recommended procedures of instrument installation, and the requirements for documentation.

- Section 3 provides a description of the monitoring program. It includes the requirements for baseline survey and monitoring prior to the SCA construction, requirements for collecting reliable data during construction, requirements for post-closure monitoring, and recommendations on data management and analysis.

- Section 4 describes the contingency plan. It includes the recommended response actions for unexpected monitoring results.

- Section 5 describes the instrumentation maintenance. It includes the requirements for maintenance of the instrumentation system during service life.

2. INSTRUMENTATION PROGRAM

2.1 Introduction

Instrumentation will be installed in the SCA and field data will be collected to assist in the evaluation of the performance of the SCA. The parameters to be monitored in the SCA include: (i) porewater pressures in the foundation SOLW at specified locations; (ii) settlement of the foundation SOLW at specified locations; and (iii) lateral movement of the foundation SOLW at specified locations near the toe of the SCA perimeter berm. In addition, porewater pressures in the Wastebed 13 dikes will be monitored.

2.2 Instrumentation Plan

A plan view of the proposed locations of instrumentation in the SCA is shown on Drawing No. 7 titled "Instrumentation and Monitoring Plan" of the Final design drawings prepared by Geosyntec Consultants in January 2010. The following instruments are planned to be installed:

- Seven sets of nested vibrating wire piezometers will be installed within the footprint of the SCA. Each set of nested piezometers will consist of three piezometers at depths of 15 ft, 30 ft, and 45 ft, respectively. The piezometers will be used to monitor porewater pressures before, during, and after the SCA construction.

- Six settlement profilers will be installed along three sections. Each section has two profile pipes (one primary and one back-up) placed in an excavated trench near the wastebed surface. The profilers will be used to monitor the settlement of the foundation SOLW under the loading from the SCA.

- Ten vibrating wire settlement cells will be installed within the footprint of the SCA. The settlement cells will be used to monitor the settlement of the foundation SOLW under the loading from the SCA.

- Four inclinometers will be installed. Two of them are located inside the SCA footprint near the proposed boundaries of Phase I. The other two are located outside the SCA footprint at the toe of the SCA perimeter berm. The inclinometers will be used to evaluate the amount of lateral movement of the foundation SOLW due to the SCA construction.

The SCA is expected to be constructed in phases. Installation of instrumentation in the SCA should be coordinated with the construction phasing.

In addition to the above-mentioned instruments, two vibrating wire piezometers will be installed on the side slope of the existing northern Wastebed 13 perimeter dike, as shown on Drawing No. 7 of the Final design drawings. These new piezometers, together with three nearby existing piezometers, will be used to monitor any change of porewater pressures in the existing Wastebed 13 dike due to the SCA construction.

2.3 Surveying and Settlement Model Calibration

In addition to the proposed instrumentation, a 50 ft by 50 ft survey grid will be set up over the footprint of the SCA. An initial survey will be performed to obtain the elevation of the existing ground. In addition, two more surveys are planned after construction of the clay liner and the gravel drainage layer, respectively, to obtain the elevations of the top of these two layers. The surveying results, together with the settlement of the foundation SOLW measured by the settlement cells and the settlement profilers, will be used to calibrate the settlement computation models. The calibrated model will be used to improve the prediction of future settlement, if needed.

2.4 Pre-Installation Acceptance Tests

The instrumentation personnel should perform pre-installation acceptance tests to ensure that the instruments and readout units are functioning properly. The U.S. Army Corps of Engineers' manual [USACE, 1995] provides a good list of items to be checked as part of pre-installation acceptance tests. According to the manual, pre-installation acceptance tests should include items from, but not limited to, the following list, as applicable:

- Examine factory calibration data to verify completeness (factory calibration and documentation should be specified).

- Examine manufacturer's quality assurance inspection check list to verify completeness (quality assurance procedures and documentation should be specified).

- Check cable length and tag numbers on instrument and cable.

- Check, by comparing with procurement documents, that the model, dimensions, materials, product performance criteria, etc. are correct.

- Bend cable back and forth at point of connection to the instrument while reading the instrument to verify connection integrity.

- Check water pressure or humidity test components as appropriate for the service entity to identify leaks.

- Verify that instrument reading as required compares favorably with factory reading.

- Perform resistance and insulation testing, in accordance with criteria provided by the instrument manufacturer.

- Verify that all components fit together in the correct configuration.

- Check all components for signs of damage in transit.

- Check that quantities received correspond to quantities ordered.

2.5 Instrumentation Installation

General installation procedures for vibrating wire piezometers, settlement profilers, vibrating wire settlement cells, and inclinometers are presented in Attachments A through D of this Plan, respectively.

2.6 Post-Installation Acceptance Tests

The installation personnel should demonstrate that the instrument was correctly installed and is functioning properly. A minimum of three readings should be made during a short span of time to demonstrate that the instrument reading can be repeated.

The installation may have an effect on the parameter which is to be measured; therefore, the instrument should be allowed to stabilize and the acceptance test repeated.

2.7 Documentation

An installation report will be prepared after completion of the installation of all instruments for each phase. The report should include a minimum of the following items [USACE, 1995]:

- Description of instruments, readout units, and other related equipment.
- Plan(s) to show as-built locations of installed instruments.
- Information of subsurface stratigraphy from boring.
- Instrument calibration and maintenance procedures.
- Instrumentation and automation documentation from manufacturers, including calibration data and warranty information.
- Pre-installation acceptance test results.
- A record of instrument installation.
- Post-installation acceptance test results.
- Names, addresses, and phone numbers of maintenance and repair sources.

The installation report should be maintained on file at the project site.

2.8 Care and Handling

All instruments should be handled carefully in accordance with manufactures' instructions to ensure satisfactory performance. Cables and tubes should be protected from nicking, bending, and kinking. Instruments installed outside the SCA footprint should be protected with a protective housing that is provided with a vented locking cap. Protective housings should be grouted into place not only to secure the cap but also to prevent surface water from flowing into the instrument. Locations of instruments, cables, and tubes should be staked with warning flags. Care should be taken by contractors during the SCA construction to prevent the damage of the system by excavation, if any, and construction traffic.

3. MONITORING PROGRAM

3.1 Introduction

The performance of the SCA will be monitored during the construction and operations and for a limited period of time after closure as determined by the Design Engineer based on monitoring results. Geotechnical data to be collected include porewater pressures and vertical and horizontal displacements. This section addresses the procedures and requirements for monitoring.

3.2 Baseline Survey

As mentioned previously, a 50 ft by 50 ft survey grid will be set up over the footprint of the SCA. Prior to the SCA construction of a phase (i.e., before the construction of perimeter berm and the liner system), an initial survey will be performed to obtain the northing, easting, and elevation of the existing ground within that phase.

3.3 Baseline Monitoring

Baseline values will be established from the instruments installed in the SCA. The following baseline monitoring will be performed prior to the SCA construction:

- The piezometers will be monitored frequently until the installation-induced pore pressures have dissipated and the steady-state is reached. Piezometers may take a significant amount of time to stabilize after installation due to drilling effects, lag time, or temperature.

- Initial readings will be taken from the settlement profilers, inclinometers, and settlement cells before the construction of the SCA commences.

3.4 Monitoring during Construction and Operations

3.4.1 Measurement of Settlement

Settlement of the foundation SOLW due to loading from the SCA will be monitored by the settlement profilers and the settlement cells. The total settlement of the foundation SOLW due to the liner system and the gravel drainage layer will be measured by surveying.

The procedure of measuring the settlement using the profiler is presented in Attachment B of this Plan. The process can be carried out as a two-man operation with one pulling the draw cord and the other booking the readings. The settlement profilers will be read bi-weekly during the construction and operation of the SCA. Under the direction of the Design Engineer, profiler readings may only need to be performed in the areas that are undergoing active filling or have been filled during the last few weeks. In addition, the Design Engineer may adjust the monitoring frequency based on the observed readings.

The settlement cells will be read automatically with a data logger. Data will be retrieved remotely from the logger using electrical cables or wireless options. The automated monitoring provides a real-time continuous observation of the performance of the SCA during construction and operations and enables a quick response to any unexpected monitoring results, if they occur.

Survey will be performed at the following stages of SCA construction and operations: (i) before and after the construction of the perimeter berm and the clay liner; (ii) after the construction of the gravel drainage layer; and (iii) before and after the placement of final cover. By comparing the measurement at different times, the total and incremental settlement of the foundation SOLW and the dredge material can be determined.

3.4.2 Measurement of Porewater Pressure

Piezometers will be used to monitor the porewater pressures in the foundation SOLW and to confirm the dissipation of excess porewater pressures that are developed as a result of the SCA construction. Potential change of porewater pressures in the existing Wastebed 13 perimeter dike will also be monitored by piezometers. Similar to the settlement cells, the piezometers will be monitored automatically using remote techniques during SCA construction and operation.

3.4.3 Measurement of Lateral Movement

Lateral movement of the foundation SOLW will be monitored by the inclinometers. Readings will be taken manually using a portable inclinometer probe and a portable readout two times a week during SCA construction and operation. The Design Engineer may adjust the monitoring frequency based on the observed readings. It is recommended that the same probe and control cable be used for each survey for consistency.

The two inclinometers inside the SCA footprint near the proposed boundaries of Phase I will be abandoned during the construction of Phases II and III liner systems, as directed by the Design Engineer.

3.5 Post-Closure Monitoring

The piezometers will be used to continue to monitor the excess pore water pressures for a period of one year or more after closure, as determined by the Design Engineer based on the observed readings. Remote monitoring techniques, as discussed previously, will be used for monitoring the piezometers. The two inclinometers outside the SCA footprint at the toe of the SCA perimeter berm are to be monitored monthly during the first two months after closure and every two months for the next four months. The Design Engineer may increase the frequency of monitoring or extend the period of monitoring based on the actual readings as they relate to the stability of the SCA. Settlement monitoring of the liner system will not be performed after closure. Post-closure visual monitoring of the existing Wastebed 13 perimeter dike will be in accordance with the Wastebed 9 through 15 Closure.

3.6 Data Management and Analysis

The management of data consists of data collection, reduction and processing, and presentation. The instrumentation manufacturers usually provide tools (i.e., hardware and software) to automatically retrieve the data from a data logger or a portable readout, interpret the data, and plot the data graphically as a function of time. For the measurement of settlement using the profiler, the data should be recorded and saved electronically (i.e., in Excel® spreadsheets) for analysis. The Design Engineer will interpret and evaluate the monitoring data in a timely manner. Based on the evaluation, the Design Engineer may request more frequent measurements or additional instruments. The Design Engineer will notify Honeywell and the contractor immediately if an unexpected condition occurs that may affect the stability of the SCA. Unexpected conditions include: (i) excessive lateral or vertical movement in a relatively short period; (ii) rapid increase of porewater pressures associated with shear movement; and (iii) significant reversal of the base liner grades.

4. CONTINGENCY PLAN

The steps outlined below should be followed when an unexpected condition occurs that will affect the stability or performance of the SCA.

In the event of stability issues:

- Temporarily suspend the SCA construction or operation in the affected area to allow the underlying SOLW to consolidate and gain strength.
- Visually inspect the SCA for any sign of cracks or bulges on the ground or on top of the SCA.
- Ensure that all monitoring equipment is working properly. Additional instruments may be installed nearby if data collected from the existing instruments is determined to be questionable due to defective equipment or installation procedures.
- Increase the frequency of readings to monitor and provide data to further evaluate the situation.
- Should excessive movement rate continue after construction work has ceased, construction of a compacted soil berm adjacent to the toe of the SCA perimeter berm may be needed.
- The solution will be executed with concurrence of Honeywell, the NYSDEC, and the Design Engineer.

In the event of significant grade reversal of the base liner that will adversely affect the flow of liquid in the drainage layer:

- Temporarily suspend the SCA construction or operation in the affected area.
- Ensure that the profilers and the settlement cells are working properly.
- Modify geotextile tube fill sequence to correct the grade reversal.

- Increase the frequency of readings to monitor and provide data to further evaluate the situation.

- The solution will be executed with concurrence of Honeywell, the NYSDEC, and the Design Engineer.

5. INSTRUMENTATION MAINTENANCE

Regular maintenance should be performed to ensure that the instrumentation systems remain in a satisfactory operating condition during their service lives. The instrumentation personnel should follow the manufacturer's maintenance schedules during the SCA construction and operations. After the SCA closure, the instrument components will be inspected as part of the quarterly final cover inspections.

The maintenance should be performed in accordance with the manufacturer's procedures. General requirements for the maintenance of the major components of the instrumentation system are discussed below:

- *Portable readout units*: Portable readout units should be protected from mishandling. The units should be kept clean and dry and checked routinely for connection and damaged parts. Batteries should be replaced as needed. In addition, the units should be recalibrated regularly following the manufacturer's instructions or sent to manufacture for calibration, adjustment, or repair.

- *Retrievable components*: Retrievable components, including wires, tubes, cables, data loggers, data controllers, and communications systems should be protected from rodents, vandals, and transient voltage surges. All plugs, caps, and covers should be maintained in good condition. Reservoirs for the settlement cells should be checked periodically and refilled as necessary in accordance with the manufacturer's instructions.

- *Embedded components*: Embedded components are normally inaccessible and maintenance is not possible. Embedded components that are accessible, such as inclinometer casings, can be inspected by downhole video cameras to determine if maintenance is required.

Any maintenance, recalibration, or replacement should be documented and reported to the Engineer. Follow-up checks should be made to verify success of maintenance.

REFERENCES

U.S. Army Corps of Engineers (USACE). "*Instrumentation of Embankment Dams and Levees*", Engineering Manual 1110-2-1908, Washington DC, 30 June 1995.

Attachment A
Installation of Vibrating Wire Piezometers

Piezometers will be installed by the grout-in method using boreholes. The installation procedures should be in accordance with the specific manufacturer's instruction and generally as follows:

1. Stake out specified installation locations, which can be performed using a hand-held GPS unit. It should be noted that the as-built locations of the installed piezometers should be obtained by a licensed surveyor. Surveying activities should be completed in accordance with the appropriate New York State rules and regulations.

2. Advance borehole to desired depth using a center hole (i.e., hollow stem) auger. During drilling, perform continuous SPT sampling over the full depth to allow characterization of the subsurface soils, if no existing borings are located within 20 ft of the borehole. Flush the borehole with water or biodegradable drilling mud.

3. Obtain pore pressure and thermistor zero readings prior to installation.

4. Saturate the filter stone with water, in accordance with manufacturer's recommendations.

5. Check pore pressure transducer calibration with the piezometer set in a bucket of water. Obtain readings for at least two different water levels.

6. Tie the piezometer to its own signal cable and lower it, with filter-end up, into the borehole to the design elevation. Nested piezometers at various depths can be installed in one borehole or separate boreholes. If multiple piezometers are installed in the same borehole, lower the deeper piezometers first. For separate borehole installation, the piezometers shall be offset from each other by about 5 ft to avoid damage to the piezometers during installation. Handle the piezometers carefully.

7. Backfill the borehole with grout specified by the manufacture. Mix cement with water first, and then add the bentonite. Adjust the amount of bentonite to produce a grout with the consistency of heavy cream. If the grout is too thin, the solids and the water will separate. If the grout is too thick, it will be difficult to pump.

8. Readings taken immediately after installation will be high, but will decrease as the grout cures. Datum readings can be taken hours to days after installation, depending on the permeability of the soil. The lag time caused by the grout itself is measured in minutes.

9. Thread piezometer cables through a PVC pipe for burial in a trench extending to a monitoring station, located outside the SCA footprint.

Attachment B

Installation and Operation of Geosyntec Settlement Profiler System

Settlement profile pipes will be installed in the SCA to monitor the settlement of the foundation SOLW under the loading from the SCA. Details of a profiler system are shown on Drawing No. 11 titled "Instrumentation and Monitoring Details" of the Final Design Drawings prepared by Geosyntec Consultants in January 2010.

The contractor shall stake out the specified locations for the pipes prior to installation, which can be performed using a hand-held GPS unit. It should be noted that the as-built locations of the installed settlement profile pipes should be surveyed by a licensed surveyor.

Before construction of the SCA, an approximately 1.5-ft wide by 1-foot deep trench will be excavated along the length of each profile line for each phase. After excavation of the trench, two 4-inch nominal diameter single-wall corrugated pipes manufactured by Advanced Drainage System (ADS) should be placed in the trench and the trench backfilled with sand. The ADS piping was selected due to its flexibility to facilitate the measurement of differential settlement.

To facilitate settlement measurements, a ¼-inch diameter polypropylene rope will be advanced through the entire length of each buried profile pipe. This rope will be used to pull the settlement profiling device through the ADS pipe. In many cases it may be advantageous to place the rope as the pipe is being installed. The ADS pipe and trench configuration discussed previously was selected such that the pipe would resist crushing due to the overburden loading of the SCA.

After the settlement pipes are installed and the trenches are backfilled, the contractor should test the pipes by pulling the transducer through each pipe to confirm that the pipe did not get crushed during installation.

Settlements will be measured using a proprietary settlement profiling system developed by Geosyntec. This system is designed to measure relative settlements at any location along the profile pipe by using a pressure transducer to measure the hydrostatic water pressure imposed on the transducer from a stationary water supply reservoir. The pressure transducer is housed within a steel or plastic "torpedo" that is pulled through the ADS pipe using a steel cable. This transducer is connected to water-filled vinyl tubing that, in turn, is connected to the fluid reservoir maintained at a constant elevation. As the transducer and vinyl tubing are pulled through the profile pipe, any change in elevation (i.e., settlement) is recorded as a pressure change on the transducer. The relative elevation of the transducer can be converted to an absolute elevation by measuring the pressure at the transducer when it is placed on a point (i.e., survey hub) of known elevation.

Adjacent to the entrance of the profile pipe, the surveyed "hub" will need to be installed and maintained for the duration of the project. Prior to each profile survey, initial readings on the transducer will be recorded by placing the torpedo and enclosed pressure transducer on the hub. The specific components that are used to conduct a profile survey include:

- ADS profile pipe installed in a trench prior to SCA construction;
- Polypropylene rope placed in the profile pipe;
- Model 15 Wika EcoTronic pressure transducer (transducer) with a built-in direct-connect (DC) signal conditioner (or compatible alternative);
- Geosyntec-fabricated torpedo device to house the transducer;
- Bundled vinyl tubing, electrical cable, and steel cable attached to the torpedo;
- Water reservoir and settlement hub located at one end of the profile lines; and
- Palm® IIIxe handheld personal data assistant (PDA) device and a MyCorder DAS 1206 analog to digital (A/D) converter; the MyCorder is a general-purpose, six-channel, 12-bit, multirange A/D device for data acquisition.

Alternate devices for recording the settlement may be used as improvements to the system are developed. To initiate a test, an initial pressure reading is obtained when the torpedo/transducer is placed on the hub. The settlement profiler device is then pulled through the profile pipe under the SCA using the polypropylene rope. To begin testing, the profiler is then pulled backwards through the profile pipe using the steel cable while stopping at pre-selected test locations to obtain readings from the transducer.

Measurements are proposed to be obtained at approximately 5-ft linear intervals along the profile length as the torpedo/transducer is pulled back through the ADS pipe. At the end of a test, the torpedo/transducer is again placed on the hub, and the final elevation readings are established. At all times during the test, the liquid reservoir is maintained at a constant elevation.

Attachment C
Installation of Vibrating Wire Settlement Cells

The installation procedure for vibrating wire settlement cells shall be in accordance with the specific manufacturer's instructions and generally as follows:

1. Stake out specified installation locations, which can be performed using a hand-held GPS unit. It should be noted that the as-built locations of the installed settlement cells should be obtained by a licensed surveyor. Surveying activities should be completed in accordance with the appropriate New York State rules and regulations.
2. Excavate a trench approximately 6-in wide and 1-ft deep extending from the location of the settlement cell to the reservoir mounted on a post located outside the SCA footprint. Remove sharp stones and rocks, if any, and place a 4-in layer of sand on the bottom of the trench.
3. At the proposed location of the settlement cell, increase the trench size as needed to fit the settlement cell and the steel plate. Place an 18-in by 18-in (or the size specified by the manufacturer) steel plate at the top of the sand layer in the trench. The steel plate helps maintain required upright orientation of the cell.
4. Place the settlement cell in an upright (vertical) position on the steel plate.
5. Cover the settlement cell with hand-compacted sand.
6. Thread cables and tubing through a PVC pipe along the trench extending to the reservoir.
7. Backfill the trench with hand-compacted sand.
8. Test the system in accordance with manufacturer's instructions to ensure it is functioning properly.

Attachment D

Installation of Inclinometers

The installation procedure for inclinometers should be in accordance with the specific manufacturer's instructions. The installation procedure generally includes the following steps:

1. A borehole is first advanced to the desired depth (i.e., a minimum of 3 feet into the native material underlying the Solvay waste) using a center hole (i.e., hollow stem) auger. During drilling, it is recommended that continuous standard penetration test (SPT) sampling be conducted over the full depth to allow characterization of the subsurface soils, if no existing borings are located within 20 ft of the borehole.

2. Place a threaded cap on the bottom of the lowest section of inclinometer casing pipe to keep the inside of the casing dry and to keep grout from clogging the casing.

3. Place a pipe clamp on the top of the casing, and manually lower this first section inside of the borehole. Install another pipe clamp on top of the second section of casing. Attach this casing to the top of the casing in the borehole. Remove the lower pipe clamp, and slowly lower the casing. This procedure of clamping and incrementally adding and lowering the rigid inclinometer casing inside the borehole continues until the casing rests on the bottom of the borehole.

4. Backfill the borehole with grout specified by the manufacturer. Take measures to counter buoyancy during grouting and allow the grout to set.

5. Install a plug on the top section of inclinometer casing to keep foreign materials and water out of the casing.